GLOBAL CLIMATE CHANGE:
THE UNCERTAINTIES AND THE CONTROVERSIES

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ABSTRACT

Uncertainties abound with respect to global climate change. Records of past climate change are imperfect because measuring devices and practices have changed and because urban areas have encroached on observation sites. Past and future climate change may be affected to uncertain degrees by volcanic eruptions, solar variability, and ocean variability. Global warming itself can interact with numerous Earth systems to produce enhanced warming--positive feedbacks--and diminished warming--negative feedbacks. Potential feedbacks present some of the greatest uncertainties about global warming. Controversy arises from the two ways of treating these uncertainties: viewing them as a reason for further study, before taking action that may be unnecessary, or as a justification for action that may avert serious if not catastrophic consequences at low or modest cost.

Much of the United States was hot and dry in the summer of 1988. So when NASA climate expert James Hansen claimed that global warming was here, intensified public concern became inevitable. But in parts of the scientific community there was just as inevitable a response--skepticism. Some experts not only saw no evidence of greenhouse warming, they saw no clear prospect of a significant warming in the future.

And yet over the past 4 years, the tempest has abated, scientific support for a middle ground has solidified, and even the Bush Administration seems to be dropping its unqualified opposition to action on the greenhouse threat. In part, the administration is hearing from the scientific community that the consensus is as strong as ever--greenhouse warming does pose a serious threat for the planet's future. Indeed, a four-agency memo recently leaked to the press hews closely to the latest assessment of greenhouse science released recently by the Intergovernmental Panel on Climate Change (IPCC). Echoing the IPCC, the memo concedes that continued increases in greenhouse gases will likely lead to ''significant changes in the climate system.''

The administration memo cited ''a consensus view of a broad range of scientists, including most U.S. scientists,'' and quoted likely limits to greenhouse warming due to a doubling of carbon dioxide as a modest 1.5ÅC at the lower end and a hefty, if not catastrophic, 4.5Å at the upper end. That's the same range that National Academy of Sciences panels have been coming up with for the past 15 years. Not that there is unanimity about greenhouse warming. Academy reports come from highly competent but very small groups. The IPCC reports each involved dozens of chapter authors, hundreds of reviewers, and a half dozen rewrites, but dissenters are still scarce in these circles. In the media they number less than half a dozen, although they are usually paired with Hansen, an environmentalist, or a mainstream scientist, giving the appearance of a raging controversy between implacable opposites. The true proportions of the debate are difficult to pin down, but there is no doubt that a consensus--in the sense of a majority opinion--exists in the scientific community.

Eventually, a quiet majority found fault with both extremes of the public greenhouse debate. For example, when Hansen, director of NASA's Goddard Institute for Space Studies in New York City, argued that the half-degree warming of the past century was driven by the steady increase of greenhouse gases, most greenhouse researchers eventually concluded that although the warming is consistent with an intensifying greenhouse, it is not clearly a result of it.

At the other extreme of the debate, questions were raised about temperature trends in general. If Earth is getting warmer, why is Minneapolis getting colder? Why isn't the United States getting warmer? Is the global warming of the past century even real? Most climatologists see no fundamental problems with the temperature trends seen so far. The lack of clear warming trends at every spot on Earth does not mean greenhouse warming is not at work, they say, because temperature varies too much to see a clear warming in every area at this early stage, even if the area is as large as the United States. And, contrary to a few critics, the globe as a whole has already warmed several tenths of a degree, even after accounting for warming due to urbanization. That a global warming is not obvious in the satellite temperature record does not surprise climatologists either. This record covers only the past decade, when temperatures were uniformly high after jumping upward in the 1970s. Climatologists are intrigued by the tendency of the warming, for the time being at least, to occur predominately during the nighttime, when presumably the least stress would be placed on living things.

The main problem with the temperature records is that greenhouse warming carries no distinctive signature that could have been clearly distinguished at this point from natural climatic variability. But if mainstream estimates of future greenhouse warming are anywhere near correct, most researchers feel, the warming should become obvious during the next decade or two as it overwhelms the coolness of the oceans and the protective effect of pollutant hazes that reflect some sunshine back to space.

Other uncertainties have been cited as justifications for complacency about the greenhouse. Could the sun possibly dim slightly during the next century and counteract any greenhouse warming? Maybe, maybe not. So many claims of a connection between the sun and climate have come and gone that most scientists believe no firm link of significant magnitude has been demonstrated. And those who do dabble in the field can't even agree whether the sun will dim or brighten in coming years. Won't plants just love the warmer, generally more moist greenhouse world rich in the atmospheric carbon dioxide that plants need for growth? Won't plants then store away the extra carbon dioxide we're putting in the atmosphere? Not necessarily. Greenhouse experiments at elevated concentrations of carbon dioxide have shown increased growth and carbon storage, but terrestrial ecologists are at a loss to predict how complex ecosystems will react. Natural plant communities might help out, but only until they get their fill of carbon, or rapid climate change might be so disruptive that the biosphere could become a net source of carbon dioxide rather than a sink. Most researchers view either salvation as dubious justification for skepticism.

Other uncertainties have attracted more serious attention within the climate community. In 1989, prominent meteorologist Richard Lindzen of MIT proposed that the computer climate models predicting a few degrees' warming for a doubling of carbon dioxide misrepresented the way that the atmosphere controls the abundance of water vapor--a greenhouse gas--in the upper troposphere. If a warming atmosphere tended to dry the upper troposphere, as Lindzen suggested, that could limit warming to a few tenths of a degree--that is, nothing to worry about (Science, 1 December 1989, p. 1118). Lindzen argued that the greenhouse effect has an inherent limit--indeed, one that has nearly been reached, due to the water vapor and other natural greenhouse gases that already warm the atmosphere by 33ÀC. Such a renegade proposal coming from a prominent researcher made front page news and prompted considerable new study. But after several years of scrutiny, most climatologists would agree that Lindzen has not proven his case. Among the strongest evidence against Lindzen's self-limiting greenhouse are satellite and balloon observations showing that water vapor in the upper troposphere increases, not decreases, whenever and wherever the lower troposphere is warmer--in summer versus winter, in the warm western Pacific versus the cooler eastern Pacific.

Most scientists in the mainstream readily admit that greenhouse science is still pervaded by uncertainties. The single largest uncertainty in the climate models is the behavior of clouds as the world warms. In one model, created by researchers at the United Kingdom's Meteorological Office, the warming due to a doubling of carbon dioxide dropped from 5.2ÀC to 1.9ÀC when the computer was switched from one ''equally plausible'' way of rendering clouds to another. Getting clouds right will take 10 to 20 years because researchers must understand better how clouds work, not just increase the speed of their computers, and then get computer clouds to act like the real ones. In addition, the interconnected system of ocean-atmosphere-biosphere has a host of ways of changing its behavior in response to warming that might in turn affect global temperature. Ice and snow, for example, might recede, exposing darker ground or ocean that would absorb more sunlight and accelerate the warming. Other possible feedbacks involve everything from methane production in wetlands to increased decomposition of soil organic matter. Most feedbacks that researchers have been able to imagine tend to enhance any warming. And most are not included in present climate models.

Uncertainties abound, but climate researchers see some constraints on the uncertainties. First there is the basic physics of the greenhouse, which is already responsible for warming Earth 33 degrees C through water vspor and carbon dioxide. This physics must continue to operate as humankind's enhancement of the greenhouse since 1765 is doubled during the next 35 year, assuming no action is taken to avoid it. And then there is the performance of climate models. They are rudimentary, everyone agrees, but their behavior bears a considerable resemblance to reality. They produce reasonable seasonal changes. They do not wildly overreact to injections of volcanic debris or small changes in solar output. With all this in mind, the IPCC has twice now accepted the 1.5- to 4.5-degree warming for a doubling of carbon dioxide as sound, characterizing their confidence in these numbers as falling midway between "virtual certainty" and "low confidence."

Given the uncertainties, some researchers are arguing for a delay of perhaps 10 years in reining in greenhouse emissions while the science settles down. If the climate system turns out to be relatively insensitive to added greenhouse gases, they reason, no harm will be done, and if it is highly sensitive, the effort to avert rapid warming will be so great that a mere 10-year delay will not make it perceptibly more harsh. Another line of reasoning is that society can adapt to climate change reasonably well and with less expense than required to limit the emission of greenhouse gases.

But environmentalists and many scientists can't agree with even this modest wait-and-see approach. Even 10 years of increasingly faster computers won't narrow the uncertainties enough, they say. A decade will see only the beginning of crucial observations of the behavior of oceans and clouds. The 1990 IPCC report foresaw the cloud and ocean uncertainties narrowing only in the 10- to 20-year range, by which point the globe might be committed to major climate change. And the ability to adapt will vary greatly from society to society;

natural ecosystems could be even harder pressed to adapt to rapid climate change.

The other reason for not waiting is uncertainty itself, some say. The possibility that greenhouse-induced change could turn out to be much more dramatic than any model predicts is spooking a generation of Earth scientists who remember the nasty surprise sprung on stratospheric ozone. No one foresaw the Antarctic ozone hole or accelerated ozone losses at mid latitudes due to natural atmospheric particles. Greenhouse specialists, too, are wondering what they might have overlooked. One possibility is an abrupt change in ocean circulation, although some studies have now discounted that idea. Or perhaps unanticipated feedbacks from polar ice caps or green plants, other workers venture.

The philosophy that many scientists are now espousing amounts to buying some insurance--in the form of no-cost or low-cost reductions in greenhouse gas emissions. Even some greenhouse skeptics, if pressed, would concede the prudence of no-cost measures that can be supported by other justifications. Greater energy efficiency seems a reasonable goal in a country that consumes energy prolifigately while importing half of its oil. While such measures fall far short of complete coverage, advocates admit, such tie-in steps seem prudent against the possibility that the higher predictions of global warming turn out to be right or some nasty surprise is lurking in the greenhouse.

REFERENCES

J.T. Houghton et al., Eds., Climate Change 1992: The Supplementary Report to the IPCC Scientific Assessment (Cambridge University Press, 1992).

W.W. Kellogg, "Response to skeptics of global warming,'' Bull. Am. Met. Soc. 74, 499 (1991).

R.S. Lindzen, "Some coolness converning global warming," Bull. Am. Met. Soc. 71, 288 (1990).